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Technology of effective microorganisms for the growth of agricultural plants of the Fabaceae family

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Abstract. This article presents the results of studies reflecting the influence of the technology of effective microorganisms (TEM) on the development of plants of the Fabaceae family (*Pisum sativum* L.). The assessment of the real effectiveness of EM agents in the mild climate of the Central Black Earth region and their influence on field germination and morphophysiological parameters of plants is given. The theoretical foundations of the use of EM agents, their role in the formation of soil microbiological communities and the assessment of their impact as a factor influencing the efficiency of legume-rhizobium symbiosis are presented. The exogenous treatment with biological products significantly increased the number and mass of active nodules on experimental plants, which contributed to the increase in nitrogen-fixing activity, which was an important component for legumes. The authors pay due attention to the assessment of the parameters of photosynthetic activity of plants under the conditions of increased inoculation with microorganisms. Not only an increase in leaf area was noted, but also a longer functioning of the photosynthetic apparatus, which led to an increase in the intensity of the work of the green surface of plants during the entire growing season. The combination of stimulating factors provided a better increase in dry biomass, which was reflected in a significant increase in the value of plant yield. The most intense accumulation of dry matter was observed in the flowering phase, which was also characterized by more intensive inoculation of plants. At the end of the growing season, this was reflected in an increase in the number of beans per plant and seeds in one bean, which had a positive effect on the crop yield indicators. The research results indicate the prospects of the use of the technology of effective microorganisms in plant growing and agriculture for the production of environmentally friendly food products and soil fertility recovery.

1. Introduction

At the modern stage of civilization development, we are forced to live in the conditions of a global ecological crisis. The era of chemical farming, which began in 1843 and continues to the present day, brought not only an increase in the efficiency of agriculture, but also inevitable environmental pollution, which entails a deterioration in the properties of the soil and a decrease in the quality of agricultural products associated with the accumulation of substances harmful to living organisms [1]. Moreover, both the release and the introduction of agrochemicals and pesticides require material resources, energy and significant labor costs. The production of nitrogen fertilizers is especially energy intensive. For these reasons, in recent years, in many countries, the question of reducing the consumption of mineral fertilizers has been raised and a search is underway for ways to mobilize nutrients that are already contained in the natural environment (in the soil itself, water or atmosphere), through the use of preparations based on soil bacteria and microscopic mushrooms [2].



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Perhaps, in connection with the research in this area, a new era in the development of agriculture begins - the era of biological agriculture. One of the areas of new agriculture is the use of the technology of effective microorganisms (TEM), or EM technology - a young, but actively developing field of production and use of microbiological preparations widely used in agriculture, medicine, as well as for the disposal of industrial and household waste.

The data of various studies on the effect of EM preparations on cultivated plants indicate that TEM can not only restore the natural fertility of soils, but also significantly increase productivity, while protecting the crop from pests of agricultural and ornamental plants and some diseases [3].

The aim of this study was to clarify the degree of influence of the technology of effective microorganisms on the growth and development of a plant of the Fabaceae family (*Pisum sativum*), to assess the real effectiveness of EM agents in the conditions of the Central Black Earth region. To achieve this purpose, the theoretical foundations of the use of EM agents and their role in the formation of soil microbiological communities were studied, the influence of the EM agent on field germination and morphophysiological parameters of plants were revealed, the impact of EM agents as a factor influencing the effectiveness of legume - rhizobium symbiosis was assessed and the effectiveness of the drug in the formation of soil fertility was determined.

The practical significance of the research is in the study of EM agents that allow creating a high concentration of beneficial forms of microorganisms in the right place and at the right time. Due to this, the introduced microorganisms can successfully compete with the aboriginal microflora and occupy the ecological niches presented to them by plants. With the use of microbiological fertilizers, the maximum productivity of the crop can be realized, due to the intensification of physiological and biochemical processes in plants, which simultaneously allows increasing resistance to stress and disease.

The purpose of the technology of effective microorganisms is to create favorable conditions for the development of beneficial soil microflora, leading to environmentally safe soil health, and, as a consequence, to increase its fertility and productivity of cultivated crops [4]. At the end of the 20th century, the Japanese scientist Teruo Higa studied about 3000 species of the main microorganisms that provide soil vital activity and discovered the essence of their regenerative-degenerative quantitative relationship. He selected 86 leading regenerative strains, which together performed the entire spectrum of functions for plant nutrition, their protection from diseases and the improvement of the soil environment. He called them EM (effective microorganisms).

Nowadays in global practice there is a tendency to reduce the doses of applied fertilizers and the role of their integrated use with agrotechnical methods aimed to maintain the natural fertility of soils, measures to increase the biological diversity of useful soil microflora is increasing. The use of microbiological agents can significantly reduce the dose of plant chemicals and mineral fertilizers. It also can make production safer and also significantly reduce the cost of agricultural products, which leads to the increase in economic efficiency [5].

The basis of all biological products is the leading regenerative strains of microorganisms. The principle of their work is in the antagonism of the organisms that make up their composition to pathogenic forms, due to which harmful microorganisms are excluded. Some biological preparations are able to increase soil fertility due to the increase of the resistance to pathogenic microorganisms. In addition to determining the level of fertility, microorganisms have a significant effect on the formation and genesis of the soil, and also play an important role in determining the productivity of the complex system soil - plant - microorganisms [6].

2. Materials and methods

The studies of the effect of technology of effective microorganisms on the growth and development of *Pisum sativum* L. plants were carried out in a moderate climate on gray forest soils of the Kursk region. In the experimental work, the seeds of sugar peas “Ambrosia” were used, provided by the group of companies “Gavrish” and agents of cultures of effective microorganisms, created on the basis of EM - technologies – “Baikal EM – 1” and “Vostok EM – 1”.

The studied agents are new generation microbiological fertilizers containing lactic acid, nitrogen-fixing, photosynthetic bacteria, saccharomycetes, actinomycetes and their metabolic products. The strains of beneficial microorganisms included in the mother concentrate Vostok EM-1 and Baikal EM-1, after additional preparation in a nutrient solution, activate the beneficial microflora, accelerate the processes of humus formation and suppress the reproduction of pathogens of fungal and bacterial plant diseases due to the competition of the nutrient medium. As a result, favorable conditions are created not only for the growth of plants and the increase in their general immunity, but also the processes of decomposition of organic residues in the soil are accelerated, which makes nutrients more accessible to plants.

The seeds of green pea plants were preliminarily subjected to calibration and disinfection. They were soaked in solutions “Baikal EM – 1” and “Vostok EM – 1” in accordance with the recommended dose (control in water) for an hour. Then they were sown in the usual row method, with row spacing of 35 cm. Then, during the growing season, the experimental plants were irrigated with solutions of preparations in a ratio of 1: 1000 (control water).

The assessment and registration of germinated seeds was carried out within the time frame established by GOST 12038-84 “Seeds of agricultural crops. Methods to determine germination”. For germination energy, the determination period was 5 days, for laboratory germination it was 10 days.

During the growth and development of plants we analyzed the morphometric parameters, the efficiency of legume-rhizobium symbiosis and assessed the physiological processes. The measurements and assessment of the effect of agents were carried out during the entire ontogenesis in different phases of plant development. The studies were carried out taking into account the method of the field experiment by B.A. Dospekhova [7], followed by statistical processing of the experimental results.

3. Results

In order to study the nature of seed germination, the germination energy and laboratory germination were determined, which reflected the ability of seeds to form normally developed, friendly seedlings for a certain period of germination (Table 1).

Table 1. Seed germination dynamics

Variant	Seed germination dynamics, %				Field germination, %
	3 days	4 days	5 days	6 days	
Control	26,5	45,0	78,2	81,2	81,2
“Baikal EM-1”	44,7	86,7	88,5	88,5	88,5
“Vostok EM-1”	42,3	79,7	82,0	82,0	82,0

Seed germination was observed on the 3rd day. The time period from the moment of germination of the first pea seeds to the maximum number of seedlings in the control variant was 6 days, in the experimental variant it was 4 days. Daily counting of the number of germinating seeds made it possible to reveal the effect of micronutrient fertilizers on the goodness of seedlings coming up. Treatment with EM - preparations made it possible to synchronize the energy of seed germination, which, in turn, contributed to overcoming the diversity of the age composition of young seedlings and narrowing the boundaries of the values of morphophysiological parameters of plants. Subsequently, the synchronization of growth and development led to the uniformity of the age composition of *Pisum sativum* L. in agriculture and contributed to an insignificant differentiation of the position of plants in agrocenoses, which led, first of all, to the absence of differences in the phases of plant ontogenesis.

The analysis of the samples on the 3rd day of development showed that the treatment of seeds with biological products had a positive effect on the process of pea seeds germination: in the experimental variants, the seed germination energy was almost 2 times higher (44.7% in Baikal EM - 1 and 42.3%

in Vostok EM - 1, 26.5% in control variant). The final result of laboratory germination was the highest in seeds treated with the preparation “Baikal EM – 1” and exceeded the control by 7%.

During the vegetation period, the features of rhizogenesis of *Pisum sativum* seedlings were studied. At the initial stages of development, the analysis of the root length was carried out: the largest average value of the root length was found in the seeds treated with Vostok EM - 1 and exceeded the control by 64%. The microbiological agent “Baikal EM – 1” showed the same effect. The difference with the control sample was 60% in favor of EM agent.

In order to study the dynamics of growth of aboveground organs under the influence of cultures of effective microorganisms, the height of the stem was measured during the entire period of active plant growth. The observations showed a more active formation of shoots in the experimental plants, which was expressed in a slightly higher plant height and leaf surface. The difference in growth at different stages of the growing season was not the same and ranged from 5.3% to 19.2% at different times.

After analyzing the data, it should be noted that at the initial stage of germination, microbiological preparations do not have a reliably significant effect on the growth and development of plants. In some samples, there was a decrease in growth rates. This is explained by the peculiarity of the initial stage of development of microbial-plant interactions: abundantly developing bacteria and microscopic fungi of the analyzed preparations have an inhibitory effect on the development of young seedlings, which noticeably inhibits their growth. This pattern is the norm at the first stages of the development of mutualistic symbiosis between soil bacteria and legumes. The difference in growth becomes reliably significant in favor of experimental samples at later stages of development of agricultural plants, which is associated with the accumulation of microorganisms of the preparation in the soil of the experimental plots and the formation of their stable populations. This led to an increase in the potential for interaction of peas with beneficial soil microorganisms, an increase in symbiotic activity and the creation of more favorable conditions for the growth of legumes.

The use of TEM had a positive effect on the size of the leaf surface, thereby improving the process of photosynthesis, which is important for high-quality harvest. The difference in the leaf surface of the experimental and control plants at different periods of the growing season ranged from 19.23 to 24.12%. The greatest differences in the surface of leaf blades were observed during the active growing season. On the 50th day of the growing season, the difference between the leaf surface of the experimental and control plants practically disappeared: this was explained by the fact that in the phase of yellowing of fruits, the distribution of assimilates changed the benefit of the reproductive organs. In this case, the relative proportion of leaves, stems, roots and reproductive organs changed. During this period, old leaves can be shed and the surface of new ones is reduced.

The biological productivity of plants is first of all the result of photosynthetic activity, during which the majority of organic compounds are formed. Therefore, the formation of the assimilating system of the leaf and the implementation of the process of photosynthesis ensures plant growth and an increase in biomass. The study of the dynamics of the growth of dry biomass in the conditions of gray forest soils showed that this process proceeds in ascending order from the beginning of seed germination to the moment of fruit ripening. The introduction of biological products increased the growth in dry biomass by 16 - 18%, which was associated with the increase in the leaf surface of plants and their increased productivity.

The activity of the assimilation surface of leaves during the growing season is characterized by the net productivity of photosynthesis, which plays a crucial role in the formation of yield. The studies showed that, on average, during the growing season, plant leaves were more productively in the variant with the use of Baikal EM-1; the increase was 3.8 g of dry matter per day per 1 m² of leaf surface, which exceeded the control by 15%. Vostok EM-1 drug increased this indicator to 13%. On average, during the growing season, the productivity of photosynthesis exceeded the control from inoculation with micronutrient fertilizers Baikal EM-1 by 12%, Vostok EM-1 by 10%. Presowing treatment of pea seeds with biological preparations contributed not only to the formation of a higher assimilation surface of plant leaves, but also to the long-term preservation of the photosynthetic potential in an active state, which contributed to an increase in the yield of dry biomass of agriculture.

One of the most important features of legumes are root nodules. Legume-rhizobial symbiosis is one of the unique models for studying the interaction between plants and microorganisms. Nodule bacteria are able to supply the legume plant with nitrogen, which is fixed from the air. And plants, in turn, supply bacteria with carbohydrate metabolism products and mineral salts necessary for the growth and development of microbial cells.

The results of the study showed that a greater number of nodules, in terms of one plant, is necessary if the seeds are pretreated with the microbiological preparation "Baikal EM - 1" or "Vostok EM - 1" before sowing into the soil. When they are treated with "Baikal EM - 1" the number of nodules reaches 74.1 pcs/plant and when they are processed with Vostok EM - 1 this value increases to 86.4 pcs/plant (Table 2).

Table 2. Number of nodules and their weight per plant

Treatment	Number of nodules, pcs / plant	Mass of nodules, g / plant
Control	44,4	31,45
"Baikal EM-1"	74,1	58,61
"Vostok EM-1"	86,4	67,02

During the treatment of EM-agent "Vostok EM - 1", the increase in the mass of nodules was observed by more than 46.3% in comparison with the control sample. Thus, the use of microbiological preparations for pre-sowing seed treatment leads to a reliably significant increase in the number of nodules on the roots of peas, as well as an increase in their mass per plant. This fact proves the stimulating effect of the preparations on the colonization of pea plants by nodule bacteria.

When the seeds ripened, a quantitative analysis of the fruits was carried out: the number of beans on the plants, the seeds of which were treated with EM - agents "Baikal EM - 1" and "Vostok EM - 1" was 34.8% and 31.5% higher than the control samples.

4. Conclusion

Thus, the agents based on effective microorganisms, as a factor affecting plant growth, are activated from the moment of swelling and germination of seeds, synchronizing the process of emergence of seedlings and, as a consequence, the rhythm of morphogenesis in plants. The most significant activity of the preparations is observed from the flowering phase, which leads to an increase in plant growth rates, the formation of generative buds, and an increase in the number of beans. Microbiological preparations showed reliably significant results indicating the effectiveness of legume-rhizobial symbiosis: treatment of *Pisum sativum* L. plants with EM preparations provided a pronounced positive dynamics in the development of symbiotic relations between nitrogen-fixing bacteria and pea plants, while control plants acquired many inactive and even partially parasitic nodules.

There is no doubt the increase in the productivity of seed peas is associated with the stimulation of plant development with biologically active substances produced by microorganisms, suppression of the development of phytopathogenic microflora and improvement in the absorption of mineral nutrition elements by plants.

The research results indicate the prospects for the use and further development of the technology of effective microorganisms in agriculture, the need to improve the EM agents and methods for the introduction of the strains they contain.

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